BRIDGE HEALTH MONITORING SYSTEM IN INCHEON BRIDGE

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Abstract

Incheon Bridge measurement system was planned focusing the maintenance of cable stayed bridge. There are GPS system, tiltmeter, cable tension meter, laser displacement meter, strain gauge, thermometer, and bridge shoe displacement meter. Additional maintenance sensors are installed on connecting bridge and viaduct for continuous bridge health monitoring system of Incheon Bridge.

Unlike other long span bridges, advanced monitoring systems were adopted for Incheon Bridge, such as Shape Management System using GPS, Earthquake Measurement System, All-the-data Time Synchronization System, Sensor Surveillance and Management System, and Intelligent Management System connecting External System. In addition, Real-time Inquiry System and Event Management System were adopted for real-

time bridge movement surveillance and event occurrence encounter.

INSTRUCTION

The length of Incheon Bridge, which links Songdo with Youngjongdo, is 18.4km. Incheon Bridge has three types, cable stayed bridge, connecting bridge, and viaduct. The main span of cable stayed bridge is 800m. Cable stayed bridge is composed of steel box girder and concrete pylons with inverse shape of alphabet 'Y'. Connecting bridge is 7 span PSC box girder type with each span length 145m. Viaduct is 50m span continuous PSC box girder.

Incheon Bridge is the special bridge and its main span is cable stayed. For further bridge maintenance, safety inspection and Bridge Health Monitoring System (BHMS below) are required absolutely. Safety inspection system manages the visual damage of each part of the bridge with the site survey. BHMS is real-time monitoring system with the sensors on major points about the bridge movement character by temperature, wind, traffic, earthquake, etc.

Other domestic bridges with BHMS are Youngjong bridge, Seohae bridge, Gwangan bridge, Samcheonpo bridge, and so on. On major structural points, each bridge has sensors like thermometer, strain guage, accelerometer, anemometer, extensometer, etc. They measure the bridge movement character by temperature change, traffic load, wind load, earthquake, etc. Bridges with long term life cycle like Youngjong bridge and Seohae bridge has their BHMS under reconstruction. Bridges with BHMS outside Korea are Tsing Ma bridge in Hong Kong and Akashi Kaikyo bridge in Japan.

Real-time monitoring about Incheon Bridge movement character is introduced for the system. First GPS system was adopted in Korea for the shape management and long-term movement character analysis of pylons and stiffening girder. Advance earthquake management system was applied for the ease.

In case of excessive wind speed, text message alarming system is adopted as the part of bridge disaster maintenance system and manages movement character by pylon displacement, stiffening girder deflection, expansion joint, bridge shoe, etc. Both ITS and BMS applied for bridge maintenance.

MEASUREMENT DEVICE AND ARRANGEMENT

Various types of sensors are installed for Incheon Bridge monitoring system. On cable stayed part, tiltmeter, thermometer, strain gauge, accelerometer, and GPS are installed for the pylon and stiffening girder movement character monitoring. Laser deflection meter and GPS are equipped in the middle of center span for maximum deflection monitoring. Seismometer is installed on the foundation of pylon and the displacement meter is on the bridge shoe. The tiltmeter are installed for pier tilt measurement on both connecting bridge and viaduct section. Laser displacement meter and accelerometer are equipped for deflection and dynamic movement management. In addition, anemometer and extensometer are installed for wind load affection analysis and expansion displacement monitoring by temperature change. Fig.1 shows the location of each measurement device.

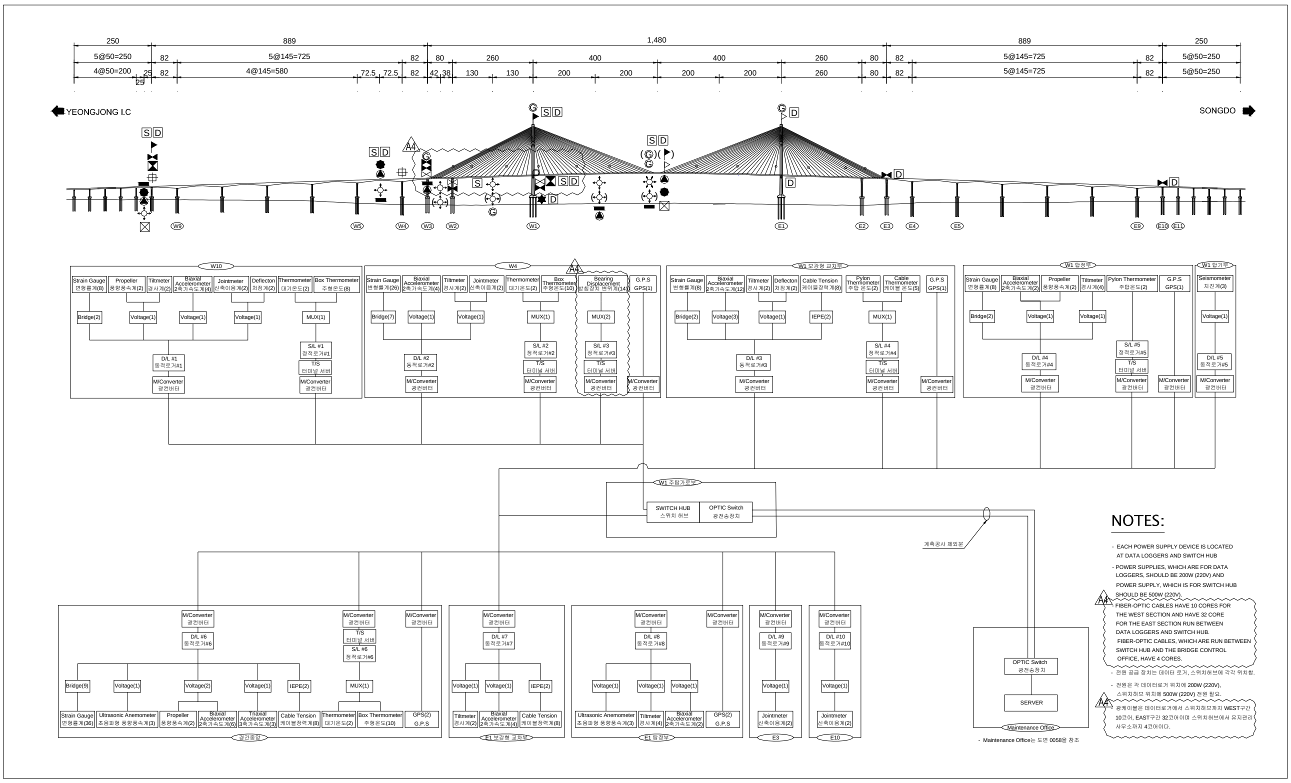

Fig.1 Monitoring instrument layout

Data Acquisition and Transfer

Slope tilt, expansion joint change, and temperature of cable stayed bridge, connecting bridge, and viaduct are measured by static data logger. Accelerometer, strain, and cable tension are measured by dynamic data logger.

Seismometer has its own data logger for sensitive measurement. Inquired data is transferred from the logger to DAQ/DB server of control system by optic cable. GPS sensor is directly connected to DAQ/DB server of control system.

For consistent data analysis from each logger, time synchronization is performed. Fig.2 shows the concept of data transfer.

Data Management System

Real-time Inquiry Program

Dynamic data from dynamic data logger and GPS sensor are displayed on the screen as graph form. Real-time received data are stored by the user and stored data are used for FFT or analysis algorithm for the user's need. During dynamic data real-time inquiry, data from each channel can be confirmed. At the time of excessive data measurement about anemometer or seismometer during real-time acquisition, triggering function

is performed for dynamic sensor's raw data storage at that time. Fig.3 shows the sample of real-time inquiry program.

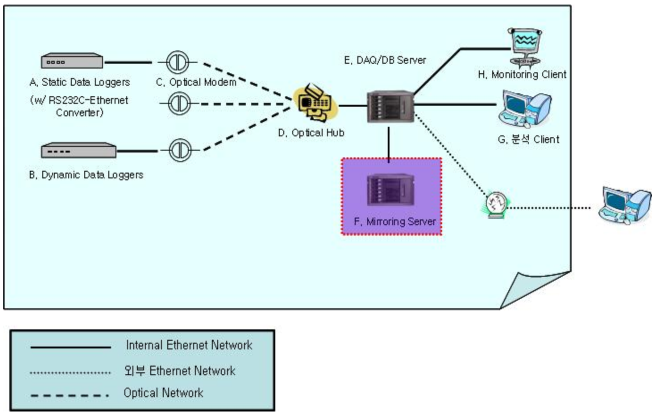

Fig.2 Data Transfer Concept

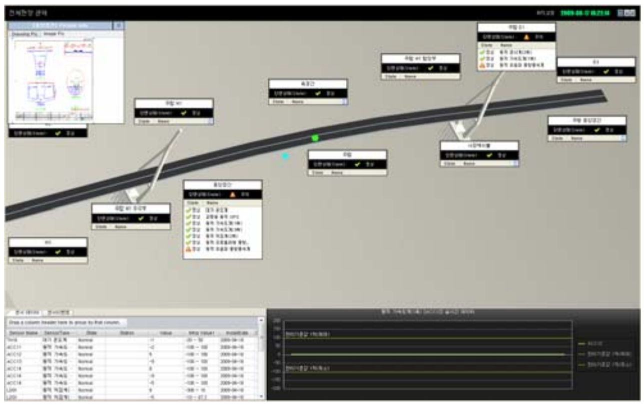

Fig.3 Real-time Inquiry System

Seismometer Data Acquisition Program

Seismometer is installed on the base of pylon and measures the earthquake affection to the bridge movement using private data logger. Applied seismometer has the bandwidth from 0.1Hz to 120Hz and its dynamic range is over 120dB. Currently, the X, Y, Z coordinates of seismometer are connected perpendicularly to each other and the event occurrence of over 0.01G (Modified Mercalli Intensity scale, or MM scale) will be stored automatically by system setting. The data of before (1~132 seconds max) and afterward (1~100 seconds max) of the event are stored at the time of event.

Earthquake exclusive software has the space for data storage and 24 Bit ADC. Fig.4 shows the earthquake data analysis software.

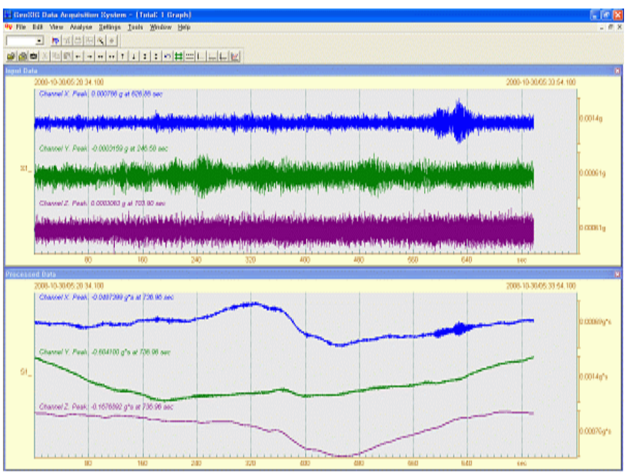

Fig.4 Earthquake Data Analysis Software

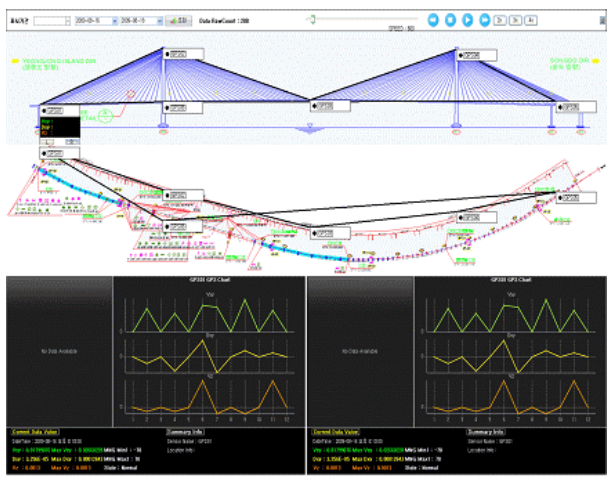

Fig. 5 GPS Exclusive Software

GPS Data Acquisition Program

GPS sensors are installed on the top of pylon and center/side span of stiffening girder for real-time bridge

shape management and long term movement measurement. Private software is used for collecting 20 GPS data samples per second by RTK (Real Time Kinemics). Separate server is installed for this system. Collected data is the whole coordinates so it should be changed into bridge coordinates for shape management. Fig. 5 shows the GPS exclusive software.

Sensor Surveillance and Management System

To discover the malfunction of the sensor at the site from the control center, NMS software applied management system is adopted. At the time of abnormal signal occurrence from the measurement program, the site manager confirms the malfunction of the sensor and repairs them. Fig. 6 shows the sensor surveillance and management system.

Integrated Event Management Program

Fig.7 shows the event management system. Event Management System communicates with the outer system or send text message to the user and manager at the time of exceeding response affection to the structure or disastrous events like extreme wind speed or earthquake. This system also examines the malfunction of the structure and analyzes bridge status for more safe bridge management.

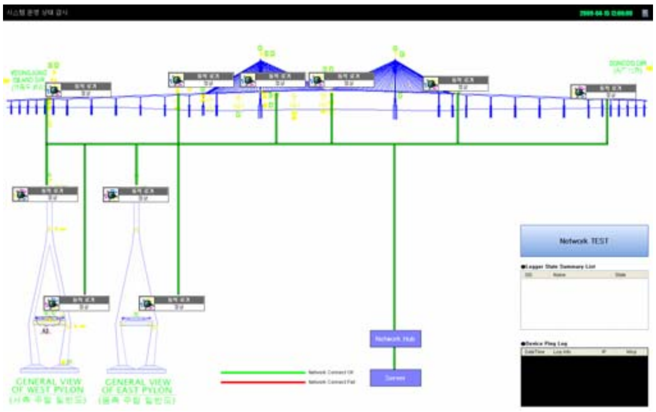

Fig. 6 Sensor Surveillance and Management System

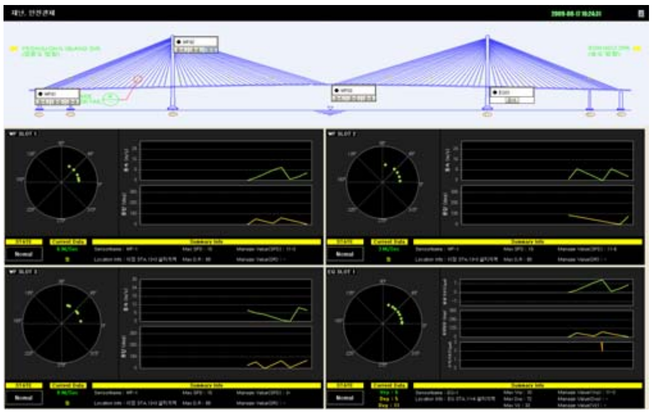

Fig. 7 Event Management System

CONCLUSION

Incheon Bridge Monitoring System was planned focusing the cable stayed bridge maintenance. Each pylon has GPS and tiltmeter and cable tension meters are installed on entire bridge. Extensometers are equipted on W3 and E3 of cable stayed bridge.

In generally, maintenance about bridge stress change measurement are performed on the center span where the bending moment is the maximum. Most of other bridges have the sensors installed convergently on the center span for bridge health monitoring.

On the other hand, we have selected the nominal section at the center span of cable stayed bridge and

planned to install the monitoring sensors. We have selected additional section between pylon W1 and pier W2, pier W2 and W3 for real movement character measurement of the bridge and built the monitoring system. These systems make it possible for the user to perform enough data history management about bridge stress fluctuation.

Furthermore, Incheon Bridge adopted GPS system, shape management system, earthquake measurement system, all-the-data time synchronization system, sensor surveillance and management system, and intelligent management system which are not applied to other bridges. Besides, real-time inquiry system for real-time bridge movement status surveillance and event management system for bridge manager and user to respond instantly at the time of event were applied.

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